THE RABBIT LAKE PROJECT

Introduction

The Rabbit Lake uranium project is located on the eastern edge of Athabasca Basin in northern Saskatchewan (Figure 2). The discovery of uranium at Rabbit Lake in 1968 was the first discovery in one of the world's richest uranium districts. That discovery was the start of extensive and highly competitive prospecting and exploration activity along the trend of the Wollaston fold belt. The activity quickly spread throughout the entire region of the Athabasca Basin, resulting in subsequent discoveries of at least 25 separate uranium occurrences, 17 of which are located along the Wollaston trend, ranging from Key Lake at the south end to Eagle Point at the north end. The district holds some of the largest and highest-grade uranium deposits found in the world.

History of the Project

Gulf Minerals Canada Limited, a subsidiary of Gulf Oil Corporation, discovered the Rabbit Lake occurrence in late 1968, the first year of active exploration in the area. Subsequent drilling indicated the presence of a major uranium deposit. Gulf sold a 49-percent interest in the project to Uranerz Canada Ltd., in 1970. Construction of a mine and mill complex began in 1972, and initial U_3O_8 production began in 1975. The project was designed for a ten-year life, with production capabilities of 4 to 5 million pounds U_3O_8 annually. Gulf continued to explore the area surrounding Rabbit Lake and by 1980 had discovered the West Bear, Horseshoe and Raven orebodies to the south of Rabbit Lake, and the Collins Bay A, B, D and Eagle Point orebodies to the north of Rabbit Lake (see Figure 2).

Eldorado Nuclear Limited purchased 100-percent interest in the Rabbit Lake project in October 1982. The project was immediately turned over to Eldor Mines, a division of Eldorado Resources Limited. (The latter is a wholly-owned subsidiary of Eldorado Nuclear Limited. Another wholly-owned subsidiary, Eldor Resources Limited, controls 16.67 percent of the Key Lake project. Figure 3 illustrates these ownership relationships.) Eldor Mines continued mining and milling at Rabbit Lake and initiated further exploration and evaluation of the Collins Bay and Eagle Point deposits. Eldor ceased mining the Rabbit Lake deposit in September 1984; the mill continued to process stockpiled ore through March 1986. However, from mid-1985 to March 1986, ore sent to the mill was blended with stockpiled ore from the Collins Bay "B" deposit to produce a more uniform feed.

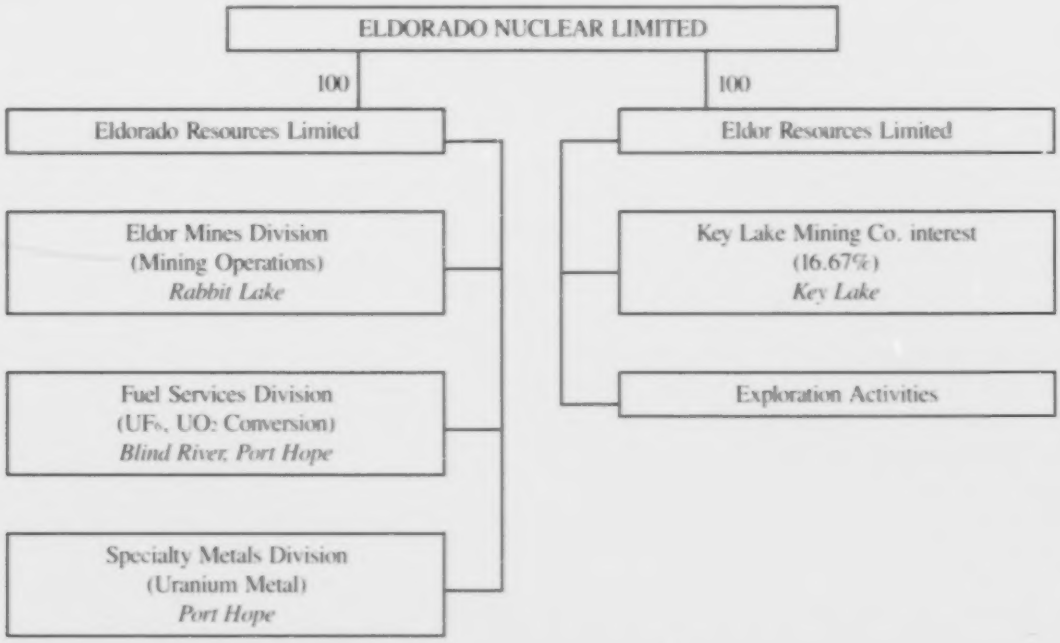

FIGURE 3. OWNERSHIP STRUCTURE OF THE ELDORADO GROUP

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RAW MATERIALS

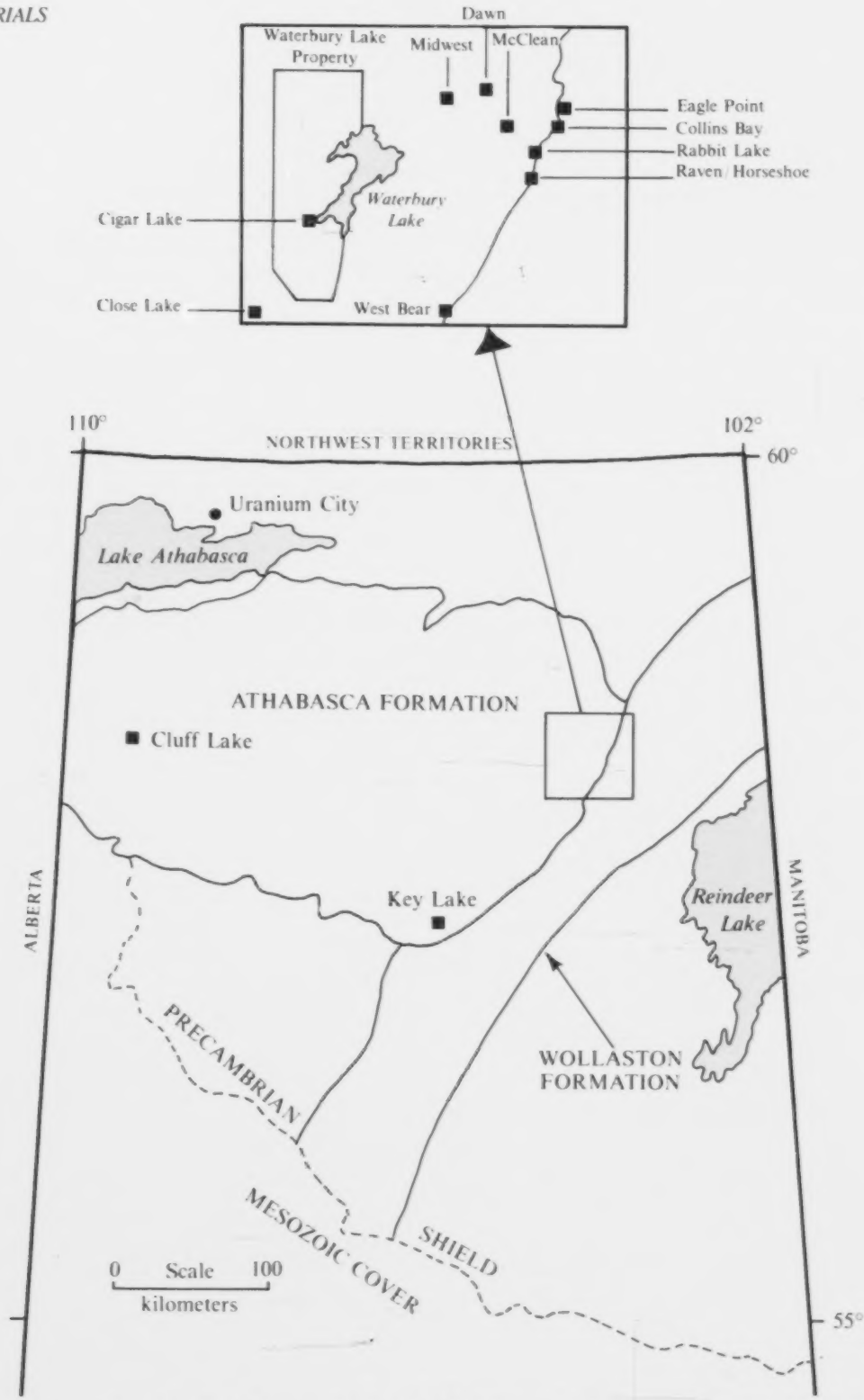

Figure 2. Location map of northern Saskatchewan, showing the Rabbit Lake project area and other uranium projects in the district.

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As of January 1986, Eldorado Resources' reserve position totaled an estimated 130,000,000 pounds U_3O_8 in the Collins Bay and Eagle Point South deposits alone. Its acquisition of the Rabbit Lake project and the highly successful drilling results led Eldorado Resources to initiate a C$100,000,000 program to modify the mill to process Collins Bay ores, develop the "B" orebody, prepare the mined-out Rabbit Lake pit to receive mill tailings, and complete evaluation and future development of the remaining orebodies. That program is proceeding — additions to the mill are now almost fully operational, all mill tailings are sent to the pit, and mining of the "B" orebody has progressed ahead of schedule. The status of ore reserves, combined with the size of the expenditure, indicates a project life of approximately another 25 years. Eldorado is now one of the world's largest uranium producers, having an annual capacity of 6,000,000 pounds from the Rabbit Lake project and about 2,000,000 pounds from its share of Key Lake production.

Project Format

Eldorado's modifications to the Rabbit Lake mill had a dual purpose — to maximize uranium recovery from the more complex and higher-grade Collins Bay ores, and to maintain new, more stringent environmental standards. The latter was accomplished primarily by eliminating the use of ammonia in the solvent extraction ion-exchange circuit and in the precipitation circuit. In the ion-exchange circuit, all uranium is now extracted (stripped) from the pregnant aqueous solution by the addition of strong sulfuric acid (450 g/l) rather than ammonia sulfate. The straight acid leach and strip action facilitates better extraction of Collins Bay "B" ore, which has a lower carbonate content than did Rabbit Lake ore. Yellowcake precipitation is accomplished with the addition of hydrogen peroxide instead of ammonia.

Mill waste water is treated with ferric sulfate and barrium chlorate to adjust the pH. It is then pumped to the settling pond area for final pH adjustment and removal of the last traces of radium. The overflow seeps through three separate sand filters before being released to the environment; radium-contaminated water is recycled through the mill.

The average grade of mill feed from the "B" orebody will approximate 0.60 percent uranium, compared to Rabbit Lake ores that averaged 0.35 percent. This permits a decrease in mining and crushing requirements. Reduced mill throughput requires less pumping capacity in the countercurrent decantation circuit (CCD), so lower-capacity pumps were installed for greater efficiency.

Impurities in Collins Bay ores include zircon, vanadium, molybdenum, iron and arsenic, compared to the occasional presence of molybdenum in Rabbit Lake ore. All impurities are precipitated out of the uranium-bearing solution by the addition of ferric sulfate and lime (about 250 pounds per ton) while passing through the solvent extraction circuit. Precipitated impurities are returned to the tails stream for final disposal. The commercial recovery of associated minerals is impractical due to poor yields of the other minerals, as well as their radium contamination. A large part of plant modification focused on tails preparation and permanent disposal. The uranium-free liquid stream (raffinate) from the solvent extraction circuit and the residue from the countercurrent decantation circuit (CCD) are neutralized with lime before being mixed and pumped to a newly constructed filter plant. Recovered fluids are recycled back to the mill; the filter cake is transferred to tailings disposal.

The tailings disposal plan is unique to the Rabbit Lake project. The mined-out Rabbit Lake pit is believed to be large enough to hold all tailings that may be generated during the remaining life of the project. Pit preparation began with the collaring of a tunnel into the southwest wall at the bottom of the pit for dewatering the pit. The tunnel was back-filled with large boulders, and the entire pit bottom was covered with a mantle of boulders. A five-foot thick layer of gravel was applied and covered with about ten feet of clean sand to form a multi-layered pervious envelope. The gravel and sand mantle will be layered up the pit walls as the pit fills with tailings, protecting the interior from outside forces.

The purpose of the gravel and sand pervious envelope is to contain all contaminants associated with mill tailings, allowing water in the tails to filter through the sand and flow through the gravel to the dewatering tunnel at the pit bottom. Similarly, migrating groundwater and surface water that would normally flow into the pit will flow down the gravel liner to the drain area, never making contact with the tailings inside the sand liner. The shaft contains three pump columns for lifting the water to the surface. Water recovered from the pit is recycled through the mill.

The transportation of tails from the filter plant to the pit was originally accomplished by loading the stacked filtercake on trucks and dumping the material directly into the pit. A new plan under development may accelerate the movement of material and allow greater control of the flow into the pit. The moisture content of filtercake is increased slightly to create a semi-liquid that will flow through a 10-inch pipeline leading from the end of the conveyor belt to a control point at the edge of the pit. At that point, the tailings flow into the pit is directed to create an even fill-up rate. If this method proves successful, permanent facilities will be installed.

The Collins Bay Project

The stripping and mining operations of the "B" orebody at the Collins Bay project are well underway. Project plans also include exploitation of the "A" and "D" orebodies. The combined

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reserves and accessibility of those orebodies is likely to add another 10 to 12 years of life to the mining and milling project. The reserve estimates for the deposits are illustrated in the following table:

Orebody	Estimated Metric Tons of Uranium	Average Grade in Percent	Estimated Total in Pounds U_3O_8
"B" deposit	11,110	0.62	29,000,000
"A" deposit	6,500	5.68	17,000,000
"D" deposit	2,150	2.19	5,600,000
	Total estimated reserves =		51,600,000

The three deposits are situated along the northeast-trending Collins Bay thrust fault (Figure 4). The "D" orebody is about 450 meters northeast of the "B" orebody, and the "A" orebody is an additional 1.5 kilometers to the northeast. Geologically, the position occupied by each orebody is controlled by reverse faulting and related alteration associated with the unconformity between rocks of the lower Athabasca Formation of Helikian age (1,800 to 1,450 million years) and underlying rocks of the Wollaston Group of Aphebian age (2,200 to 1,800 million years). The Wollaston Group unconformably overlies Archean basement rocks. The footwall of the thrust zone consists of metasediments, made up primarily of granitoid gneiss; the hanging wall consists of graphitic gneiss. Both units belong to the

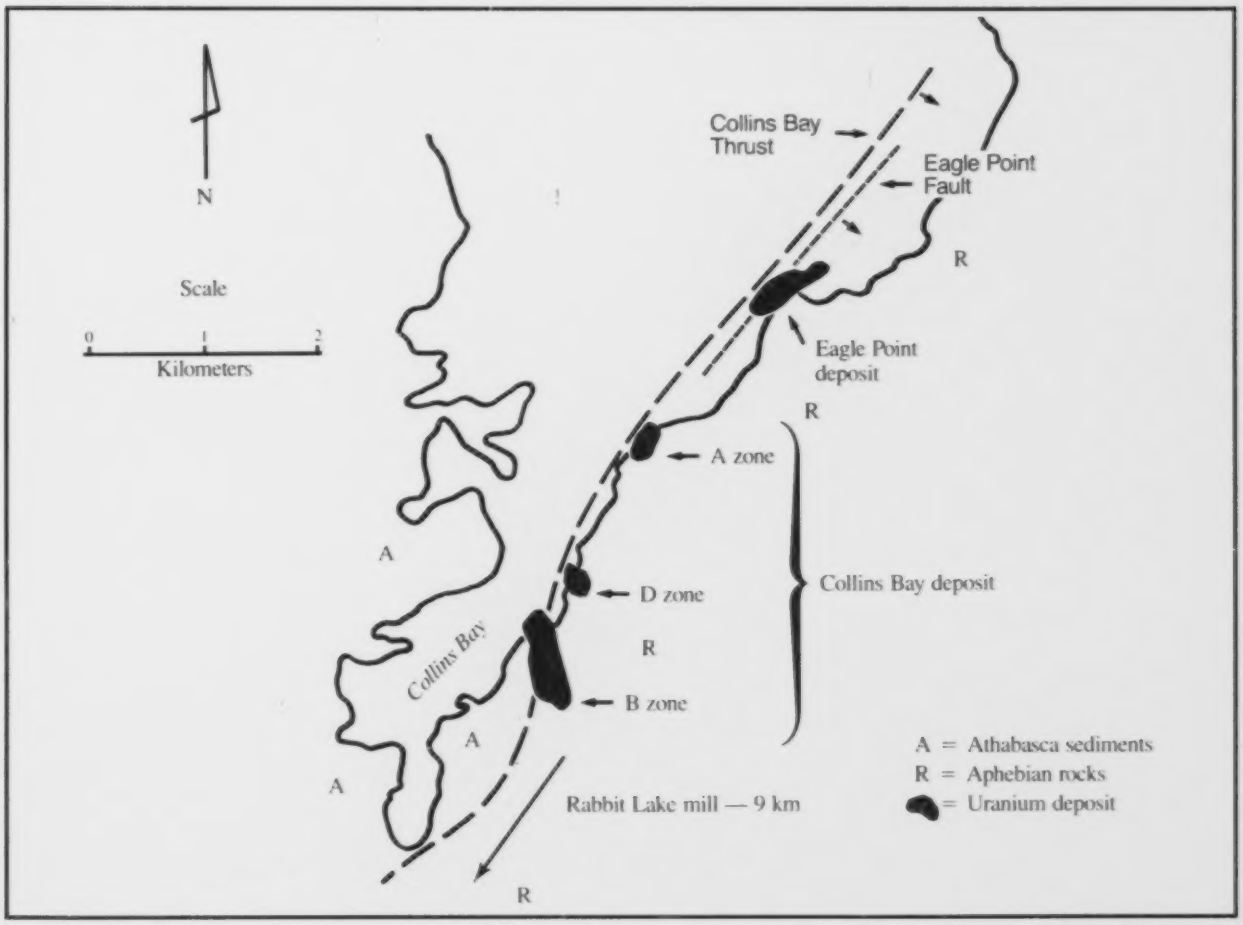

Figure 4. Geologic position of the Collins Bay and Eagle Point uranium deposits along the Collins Bay thrust and Eagle Point fault. (After Sibbald, 1983.)

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Wollaston Group. Ore deposits are situated on both sides and within the thrust zone, usually within the faulted remnant of the Athabasca Formation. However, mineralization may also occur in thin and highly altered segments of Aphebian rocks.

The actual host rock for the three Collins Bay orebodies is the Manitou Falls Formation, the lowest segment of the Athabasca Group that is present locally. Uranium mineralization is associated with a zone of intense argillic alteration and may extend downward to occupy the upper part of the regolith alteration zone at the Aphebian/Helikian contact. A halo of nickel mineralization shows close association with the uranium.

The mineral-forming process in the district followed deposition of the Athabasca sediments. Mineralization accompanied a period of widespread hydrothermal activity and associated rock alteration predated by regional tectonics and metamorphism of older rocks. Mineral accumulations occurred under favorable host conditions related to continued rock deformation and alteration. The age of mineralization is estimated at about 1,100 to 1,340 million years.

The "B" Orebody

Final evaluation and preparation of the "B" orebody was completed and stripping initiated in March 1985, and the first ore was mined and stockpiled in May. Mine production is currently progressing ahead of schedule, both in terms of tonnage mined and the average grade of ore. The "B" orebody is located nine kilometers northeast of the Rabbit Lake mill. It was discovered in 1977 by Gulf Minerals Canada Ltd., following detailed geological and geophysical studies in the immediate vicinity of the "A" orebody, discovered in 1971. Continued evaluation by geophysical techniques and diamond drilling on a number of electromagnetic conductors leading from the "A" zone led to the discovery.

Drilling revealed that the important zone of mineralization measured approximately 3000 feet long, 100 to 400 feet wide (average width is 300 feet) with an average thickness of about 100 feet. The bulk of the ore is in sandstone of the Manitou Falls Formation. The highest grade ore (2 to 4 percent U_3O_8) occurs in association with a clayey alteration product derived from Aphebian and basement rocks which were thrust, or squeezed, into the Manitou Falls sandstone. Rock alteration accompanied by high-grade ore is more pronounced where the mineral zone makes a sharp bend to the northeast at the north end of the deposit.

The orebody actually consists of a series of layered high-grade lenses enclosed by lower-grade ore. The high-grade material is usually confined to altered clay zones. Massive pitchblende is the main uranium mineral present in the clays; niccolite is the main source of nickel arsenides. However, the bulk of mineralization is confined to interstitial fillings and coatings of quartz grains in the sandstone. The main uranium minerals are pitchblende and coffenite; nickel arsenides present are gersdorffite and niccolite. Galena, chalcopyrite and pyrite are less common associated minerals.

Eldor is mining the "B" orebody using open-pit methods. Approximately 20 million tons of waste and ore will be removed, leaving a pit about 900 meters in length, up to 400 meters in width, and 60 to 70 meters in depth. The overburden, which was removed in 1985, consisted of a mantle of muskeg and glacial till 12 to 20 meters thick. It was removed and stockpiled separately for reuse around the site and final reclamation of the pit.

About 150 meters of the north end of the deposit extend into Collins Bay, covered by about 6 meters of water and 12 meters of glacial till. Dikes were installed to allow mining access to the ore (Figure 5). The main portion of the dike was constructed of interlocking steel sheet dam cells, each filled with compacted sand. Earthen dike extensions onshore, isolating the orebody from bay waters. Once the water had been pumped out, strip mining began.

The ore zone is so completely altered that mining is accomplished with little or no blasting, although ripping may be necessary. The mine rate is 1,800 tonnes of ore per day using front-end loaders for closer grade control. The mined ore is hauled from the pit using the same 27-tonne dump trucks and stockpiled nearby according to estimated grade. It is blended from stockpile to maintain a suitable yellowcake production level.

The "A" Orebody

Gulf Mineral Resources discovered the "A" orebody in 1971 during geologic reconnaissance of anomalous radioactivity in glacial material. Ground exploration led to the discovery of a mineralized boulder train; subsequent geophysical studies and follow-up drilling resulted in the ore discovery. The orebody is situated on the hanging wall of the Collins Bay thrust. It is entirely within highly altered Manitou Falls Formation immediately above the contact with Aphebian rocks and Archean granitoid and graphitic gneisses and metasediments (Figure 6). The orebody host is a lens of well-developed clay alteration. A halo of nickel mineralization surrounds the uranium mineralization.

The orebody measures about 90 meters along the thrust, 45 meters wide and only 30 meters in depth. The highest-grade uranium occurs in the center of the deposit as lenses and seams of pitchblende in hard dark clay; ore intercepts grading up to 80 percent U_3O_8 have been recovered from drill cores of this zone. Coffenite is present as a companion mineral in the lower-grade zones. Ore quality and quantity decreases with depth and completely bottoms out after penetrating about 6 meters into altered basement rock. Nickel arsenides (niccolite and rammelsbergite)

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are dispersed throughout the uranium, but show higher concentrations in areas of softer clays which are peripheral to the high-grade core. Traces of silver, gold and galena have been noted throughout the orebody. Uranium is the only mineral present in sufficient quantities to be of commercial interest.

The "A" orebody will be strip mined on a schedule favorable to the mining of the "B" orebody. The high-grade nature of the deposit will be beneficial to later-stage mining of the "B" orebody. The north end of the deposit extends into Collins Bay and will require the construction of dikes before mine development begins. Water depth and the thickness of the glacial till are similar to those conditions at the "B" orebody. The timing of the development is still under construction.

The "D" Orebody

The "D" orebody is the smallest of the three deposits included in the Collins Bay project. Nevertheless, it is important to the overall program. It is a small but high-grade deposit, can be strip mined with ease and is located in close proximity to the mill. Some diking may be necessary to develop the deposit fully. The mining schedule will probably coincide closely with that of the "A" orebody.

The "D" and "A" orebodies are structurally, geochemically and morphologically similar deposits. The largest part of the "D" orebody occurs in alteration clays and sandstone within the Manitou Falls Formation, all on the hanging wall of the Collins Bay thrust. It is about 120 meters long, 7 to 42 meters wide and about 28 meters thick. Minor amounts of ore occur in fragments of altered Aphebian and Archean rocks that have pushed into the Manitou Falls. In the sandstone portion, pitchblende and nickel arsenides occur as intergranular fillings and coatings of sand grains. Pitchblende forms as massive pods and vein-filling material. Massive pitchblende with niccolite is more common to the clay zones. Other minerals present in minor amounts include uraninite, coffenite, gersdorffite, galena, chalcopyrite, pyrite and graphite.

Figure 5. Photograph of overburden being stripped following the completion of dike construction on the Collins Bay "B" deposit.

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Eagle Point Project

The most recent discovery in the area was made at Eagle Point, located on Collins Bay about 12 kilometers northeast of the Rabbit Lake mill (and about 5 kilometers northeast of the "B" orebody). The Eagle Point deposit was discovered in 1980 during a diamond drilling program designed to test the northeast extension of the Collins Bay thrust zone. High-grade mineralization was discovered on the southeast side of the thrust, and was followed southeast where the Eagle Point fault was discovered.

Exploration and delineation drilling during the next four years outlined an orebody estimated to contain about 130 million pounds U_3O_8. The orebody dimensions are currently about 1,130 meters in length, 185 to 400 meters in width, and extend from the surface to a drilled depth of about 400 meters. Approximately 80 percent of the orebody lies directly under 10 to 15 meters of water in Collins Bay.

The deposit is divided into Eagle Point South, which is 100 percent controlled by Eldorado and contains an estimated 78 million pounds U_3O_8; and Eagle Point North, controlled equally by Eldorado, Saskatchewan Mining Development Corporation (SMDC), and Noranda Mines Limited and contains an estimated 52 million pounds. Eldorado is the operator of the joint-venture project. The entire property, but primarily Eagle Point South, is included in the long-range planning for the Rabbit Lake project.

Uranium at Eagle Point is closely associated with the Eagle Point fault, a parallel structure to the Collins Bay thrust which is located only about 45 meters to the northwest. The highest grade uranium mineralization (up to 60 percent U_3O_8) occurs as fracture fillings and as impregnations in large lenses of highly altered gneissic and intrusive rocks adjacent to the fault zone. However, uranium mineralization occurs in all rock types influenced by fault-related fracturing and rock alteration. The actual fault zone, which is only 1.5 to 3 meters wide, is filled with graphitic gouge containing only spotty mineralization. Important uranium minerals present include pitchblende and uraninite. Boltwoodite, and alteration product of uraninite, is widely distributed throughout the deposit, and coffenite occurs in minor amounts. The nickel arsenides and associated minerals common to the A, B and D deposits occur only in trace amounts in the Eagle Point deposit.

Development plans for Eagle Point are uncertain at present. It is likely that the deposit will be mined completely by underground methods because most of the deposit is under water. The next phase of planning calls for review of engineering proposals for underground exploitation. Mining will coincide with the depletion of the three Collins Bay deposits in order to maintain established production schedules, indicating that a full-scale development program could be initiated within six to eight years.

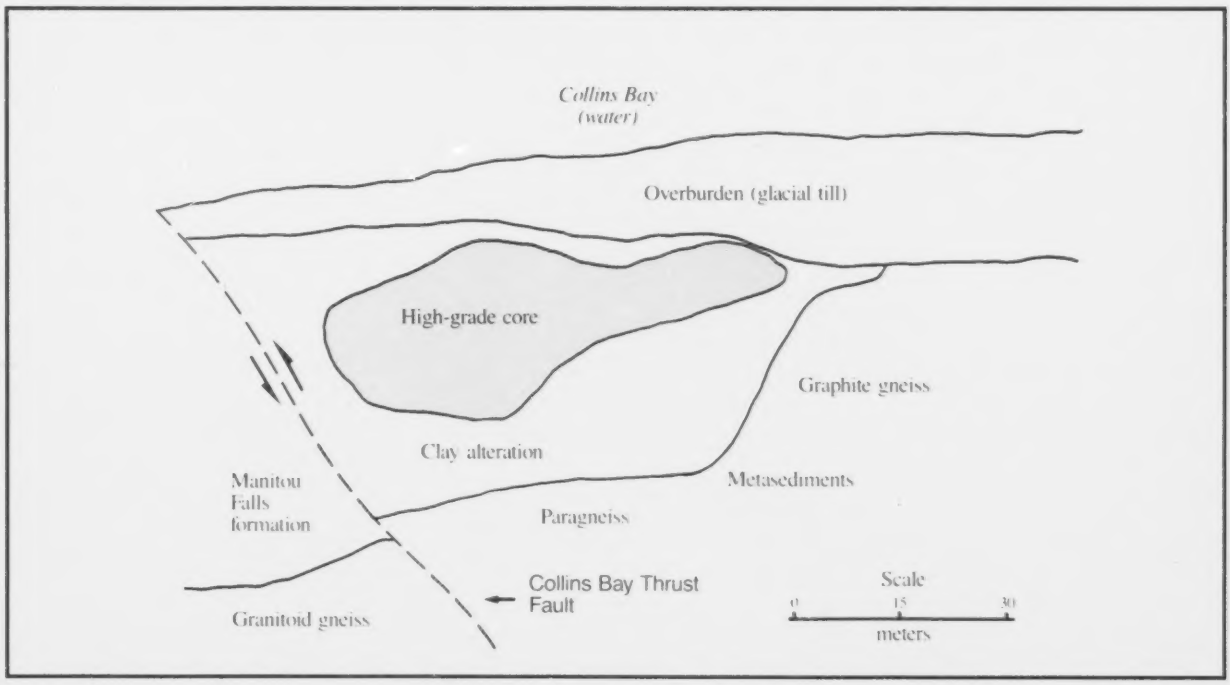

Figure 6. Vertical cross-section through the high-grade portion of the "A" orebody, showing relationship of the core to the clay alteration zone. (After Jones, 1980.)

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